

**REPORT DOCUMENTATION PAGE**

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<b>1. AGENCY USE ONLY (Leave blank)</b>	<b>2. REPORT DATE</b>	<b>3. REPORT TYPE AND DATES COVERED</b>	
<b>4. TITLE AND SUBTITLE</b>		<b>5. FUNDING NUMBERS</b>	
Air Force Future Aerospace Science and Technology Cntr.		Agreement No. F49620-95-1-0526	
<b>6. AUTHOR(S)</b>			
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<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b>		<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
Howard University Dept. of Systems and Computer Science 2300 6th St., NW Washington, D.C. 20059			
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b>		<b>10. SPONSORING / MONITORING AGENCY REPORT NUMBER</b>	
Air Force Office of Scientific Research		20030915 033	
<b>11. SUPPLEMENTARY NOTES</b>			
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b>		<b>12b. DISTRIBUTION CODE</b>	
Approved for public release, distribution unlimited			
<b>13. ABSTRACT (Maximum 200 Words)</b>			
<p>In keeping with the primary objective of the grant, the HUFAST research team designed and developed tools to assist in the development of component-based, fault-tolerant C<sup>4</sup>I systems. During the first two years of this effort the HUFAST research program focused on fault-tolerant issues involving C<sup>4</sup>I systems in distributed environments. The work researched fundamental problems in software engineering, with special emphasis on those problems most common to avionics. This period provided the basis for the middle two years where the research emphasized more technical results. Further these middle two years allowed us to apply our earlier results and direct our efforts more towards issues of fault-tolerance in targeted heterogeneous applications. The avoidance of single points of failure in distributed, component-based systems was emphasized. The primary purpose of our research was realized during the latter two years of the project with the creation of a Software Development Kit (SDK) comprised of methods and tools to assist the developers of fault-tolerant, component-based software for avionics and aerospace.</p>			
<b>14. SUBJECT TERMS</b>		<b>15. NUMBER OF PAGES</b>	
		<b>16. PRICE CODE</b>	
<b>17. SECURITY CLASSIFICATION OF REPORT</b>	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b>	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b>	<b>20. LIMITATION OF ABSTRACT</b>

**HOWARD UNIVERSITY  
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Washington, DC 20059**

**AIR FORCE  
FUTURE AEROSPACE SCIENCE AND TECHNOLOGY  
(HUFAST) CENTER**

**FINAL PERFORMANCE REPORT**

**AGREEMENT NO. F49620-95-1-0526**

*Submitted to:*

Dr. Robert L. Herklotz  
AFOSR/NM  
Program Manager: Software and Systems  
Air Force Office of Scientific Research

*Submitted by:*

Dr. Harry N. Keeling, Principal Investigator

**AUGUST 2003**

**(HBCU/MI FAST95) HOWARD UNIVERSITY AIR FORCE FUTURE AEROSPACE  
SCIENCE & TECHNOLOGY (HUFAST) CENTER  
F49620-95-1-0526**

Final Performance Report  
16 October 1996 - December 2002

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## **OBJECTIVES**

HUFAST was begun in 1996 with a mission of conducting research for the Air Force directed at improving the fault-tolerant ability of mission critical systems for Command, Control, Communications, Computers and Intelligence (C<sup>4</sup>I). At the HUFAST center we recognize that modern C<sup>4</sup>I software systems are often comprised of heterogeneous components built over time with different programming languages and by different development teams. The components of these systems come from many places, such as local and remote objects, subsystems, reused components, COTS products, databases of various types, graphical user interfaces, and more. Subsequently, part of the HUFAST research program is focused on fault tolerant issues involving C<sup>4</sup>I systems in distributed environments. The avoidance of single points of failure in distributed, component-based systems was emphasized. The HUFAST research team continues to build and maintain a laboratory environment where software fault-tolerance research can be conducted using several hardware and software platforms.

Another major goal of the HUFAST Center is to develop and maintain a quality multidisciplinary research program that focuses on issues related to fault-tolerant distributed systems for C<sup>4</sup>I. The Center seeks to add to the body of knowledge in the area of fault-tolerant systems and to develop methods and tools to positively impact the life cycle of such systems. In addition, the Center attracts and trains minority engineers who can impact on the future technological needs of the Air Force (AF), the Air Force Office of Scientific Research (AFOSR), and the nation.

In the first three years, HUFAST researchers performed fundamental work in software engineering, especially reuse and reliability, in simulation of distributed systems, and distributed geographical databases. In the latter three years the efforts of this project were directed toward more technical objectives building on research findings from this earlier work.

## **ACCOMPLISHMENTS**

In keeping with the primary objective of the grant, the HUFAST research team designed and developed tools to assist in the development of component-based, fault-tolerant C<sup>4</sup>I systems. During the first two years of this effort the HUFAST research program focused on fault-tolerant issues involving C<sup>4</sup>I systems in distributed environments. The work researched fundamental problems in software engineering, with special emphasis on those problems most common to avionics. This period provided the basis for the middle two years where the research emphasized more technical results. Further these middle two years allowed us to apply our earlier results and direct our efforts more towards issues of fault-tolerance in targeted heterogeneous applications. The avoidance of single points of failure in distributed, component-based systems was emphasized. The primary purpose of our research was realized during the latter two years of the project with the creation of a Software Development Kit (SDK) comprised of methods and tools to assist the developers of fault-tolerant, component-based software for avionics and aerospace.

### **Early Years**

During this period the research team developed models and methods that reduced the number of residual faults remaining within programs. Also, we researched the efficiency of techniques used to reduce this number. Among the methods studied were: formal methods, fault injection, assertions, exceptions and exception handlers, testing techniques, and variations in review techniques. The result is a metrics-based modeling technique that is useful during different stages of the software life cycle to improve the fault-tolerance and reliability of software systems. Much of this effort was focused on validation of a metric used for measurement of potential interaction between source code modules. This metric, called the BVA metric, is based on the number of data elements passed between program subunits and the type of these data elements. The BVA metric was presented publicly at the IEEE-sponsored conference COMPASS'97 and details of the metric were reported in the annual progress report.

Another noteworthy accomplishment during this period was the EDAT software reliability growth tool. It is now in its third generation and has been applied to several sets of industrial software reliability data for calibration. In order to reduce complexity of the resulting analyses, research is also underway in the use of neural nets to improve the visualization of software reliability data.

During years 2 and 3 we focused some of our efforts into the area of supercomputers. Supercomputers are widely used in many of the real time engineering applications like

computational fluid dynamics, weather forecasting, communication, graphical animation, simulation and physical modeling. The computational power requirements for today's real time applications are enormous and a programmer or user needs to know the computational power capabilities of such Supercomputers. Thus, it is necessary to evaluate the performance of the Supercomputers to keep track of its usage and, thereby, to make appropriate machine selection for implementing the desired application. The supercomputer performance measurements involve study, analysis and evaluation of the entire system including hardware and software. The accomplishment of this research was the Linear Algebra PACKage (LAPACK) benchmark technique. The technique produced a primary source of routines for solving a large number of applications hence it was taken as the standard for testing parallel machines. The results from this study showed that the CRAY C90 machine was about 45 times faster than the KSR-1 machine in executing the Cholesky factorization routine. In terms of the MFLOPS rating, the CRAY C90 machine has shown a peak performance of 4.85 GFLOPS, whereas the KSR-1 has shown the peak performance of 107.78 MFLOPS.

### **Middle Years**

During this period the research was influenced heavily by the revolutionary changes in the software industry due to the influence of Java and the Internet. We are using a systematic approach to evaluate the effect of Java and the Internet on fault-tolerant software development. This work is in addition to our work with other programming languages and with language-independent features.

Per the suggestion of the contract manager, we have revised our research approach to emphasize technical results. Subsequently, we began to concentrate our attention on issues of fault-tolerance in component-based heterogeneous applications as it relates to Command, Control, Communications Computers and Intelligence (C<sup>4</sup>I). Toward this end, we have put in place an Air Force-relevant test bed of hardware and applications to support our research and experimentation. Our long-term goal to enhance our capabilities in distributed system fault-tolerant research has been furthered through new relationships (corporate and government), the development of a HUFAST research library, and the upgrading of our research lab. Our home page <http://www.hufast.howard.edu/> has furthered our technology transfer objectives.

### **Last Two Years**

The later work on this grant focused on researching NASA's Integrated Test and Operations System (ITOS) that is used to control its suite of small satellites. We were granted permission from NASA to use the WIRE spacecraft, and its command and control system ITOS, as a test bed for our research.

After being granted permission to use and access to NASA's WIRE spacecraft and its command and control system, the Integrated Test and Operations System (ITOS), we made major strides in the documenting and understanding this sophisticated software. We have analyzed and documented this system, at the source code level, and worked closely with NASA representatives to devise a strategy for (1) distributing its software modules and (2)

making ITOS more fault-tolerant. Our framework design is based on a distributed object model. Also, we have installed and experimented with several CORBA ORBs and we have researched other products (e.g. UC's Eternalm) to assist in making ITOS more fault-tolerant.

Through weekly trips to NASA and visits from NASA personnel, we designed and developed a hybrid version of ITOS that will be operationally equivalent and fault-tolerant. We are utilizing this hybrid version of ITOS to prove our approaches and to develop new methods/tools for designing and building software for fault-tolerant C<sup>4</sup>I systems.

One noteworthy result of this research is a new method for the application of object-oriented, fault tolerance to NASA applications. This approach is centered on a cohesive software object, which bundles application data, measures of the object's reliability and methods for calculating its reliability. To assist ITOS in handling faulty data, HUFAST researchers have developed an approach for self-calculating risk metric data objects (SCRMDO). The use of SCRMDO for fault tolerance in a mission-critical system was illustrated by simulating its use in the ITOS telemetry subsystem. Another result has been the development of a final version of the HUFAST Documentation Assistant. This tool has been introduced to NASA representatives and it will help them build the next version of ITOS and other software packages.

We researched the use of this metric to indicate the risk of inaccuracy due to unreliable algorithms calculating the application data value, the risk of data corruption during transmission and the risk of data corruption due to malicious activities. One benefit of the approach is its broad applicability due to its use of a risk metric that encompasses faults with diverse origins. Another benefit of these techniques is their modularity since self-calculating data objects can be modified in either an actual system or an executable system model without requiring changes to other software components. Further, this approach is robust since decision mechanism algorithms can compensate for the faults.

Our research team designed and developed a hybrid version of ITOS that is operationally equivalent and close to 100% fault-tolerant. In future years, we will utilize this hybrid ITOS to prove our approaches and to develop new methods/tools for designing and building software for fault-tolerant C<sup>4</sup>I systems.

We conducted research investigations in the area of software reliability modeling with emphasis on model improvements. We are continuing this work with emphasis on model improvements.

Toward these goals, we are developing maintenance and user documentation for ITOS. These efforts will not only give our team an intimate understanding of the ITOS software, it will also provide use with guidance in our task of distributing ITOS using Eternal™ and CORBA.

The HUFAST research team studied, documented and modified additional representative aerospace applications to be used as test beds for F/T techniques and we added new test bed components. We further enhanced our test bed to support research in fault-tolerant distributed aerospace software by upgrading software and internet tools to facilitate research

The primary goal of this research is to address the fault-tolerance of the Jini environment by making the lookup service more robust. Fault-tolerance will be achieved through the use of redundancy in the lookup service. We also introduce the use of an additional protocol that will handle the replication of lookup services, and which will mask any faults in the network from the user to ensure continued service in the presence of failures. Lastly, we will provide an application that manages lookup services as active or passive replicas.

Software reliability and dependability of CORBA applications constitutes a major problem since the software complexity increases the likely-hood of software design errors. Although there is much on going work to provide ORB-level fault-tolerance, there is not much work on techniques for constructing reliable and dependable applications across the ORB. The primary accomplishment of this research was an object-oriented design pattern for constructing reliable CORBA applications using software design fault-tolerance.

## **PERSONNEL SUPPORTED**

### **Faculty**

Coleman, Don M., Ph.D.  
Bryson, Noel, Ph.D.  
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Keiller, Peter, Ph.D.  
Leach, Ronald J., Ph.D.  
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Shurn, Todd, Ph.D.  
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Keeling, Harry N., Ph.D.

### **Post-Docs**

None

### **Graduate Students**

Charles, Claude  
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Justice, Clennita  
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**Other (Undergraduate Students)**

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Massell, Anika  
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Rwebangira, Mugizi  
Seilbea, Lorna Hilda  
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Dennis, Raven  
Folarin, Tolulope  
Gill, Joseph  
Gatling, Teia  
Alami, Lamia  
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Folarin, Tolulope  
Martinez, Camilo  
Mason, Dale  
Richardson, Cory  
Rwebangira, Mugizi  
Seilbea, Lorna Hilda  
Spencer, Richard  
Taylor, Adegbemiga  
Tolson, Michael (from Hampton University)

Dr. Percy Pierre, Consultant

Mr. Goodson, Adolph, Research Associate  
Ms. Sharon Lacy, Administrative Support

## **PUBLICATIONS**

### **Books/Book Chapters**

"Software Cost Estimation," Encyclopedia of Electrical and Electronics Engineering, John Wiley, New York, 1999. (Leach)

"Software Engineering," Addison-Wesley.

"Software Metrics, A Rigorous Approach," International Thompson Publishing Company.

"Software Metrics: A Tutorial," IEEE Press.

### **Journals**

"A Reengineering Process Using Early Decomposition And Simple Tools," Information and Software Technology, (R. Leach, C. Charles, K. Fagan, T Kimbrough, and K. R. Thomas).

"Generating Consensus Fuzzy Cognitive Maps", Intelligent Information Systems, ed. Professor H. Adeli, IEEE Computer Society, Los Alamitos, CA. (1997).

"An Action Learning Evaluation Procedure for Multiple Criteria Decision Making Problems", European Journal of Operational Research 96, 379-386 (1997).

"Generating Belief Functions from Qualitative Preferences: An Approach to Eliciting Expert Judgments and Deriving Probability Functions", Data & Knowledge Engineering, in press (1998).

"A Qualitative Discriminant Approach for Generating Belief Functions", IEEE Transactions on Knowledge and Data Engineering, in press (1998).

"W-Efficient Partitions and the Solution of the Sequential Clustering Problem", Annals of Operations Research: Nontraditional Approaches to Statistical Classification and Regression, in press (1998).

"Enhancing the Predictability of two popular Software Reliability Growth Models" , South African Computer Journal , November 1999, (South Africa) (Keiller and Mazzuchi)

### **Refereed Papers Published**

"Generating Belief Functions from Qualitative Preferences: An Approach to Eliciting Expert Judgments and Deriving Probability Functions", Data and Knowledge Engineering, in press (1998).

"A Qualitative Discriminant Approach for Generating Belief Functions", IEEE Transactions on Knowledge and Data Engineering; Vol. 10, No. 2, 345-348, (1998).

"W-Efficient Partitions and the Solution of the Sequential Clustering Problem", Annals of Operations Research: Nontraditional Approaches to Statistical Classification and Regression; in press (1998).

Towards Modeling the Query Processing Relevant Shape Complexity of 2-D Spatial Objects submitted to Information and Software Technology, July 1998.

"Constructing Reliable Software Components Across the ORB", R. Rwebangira and L. Burge, ADMI, 2000.

"A Ubiquitous Stable Storage for Mobile Devices", S. Baajun and L. Burge, ACM Symposium on Applied Computing, 2001.

"Improving the Performance of the Goel-Okumoto Software reliability Growth Model using censored data analysis techniques" at The Annual Reliability and Maintenance Symposium (RAMS) January 2000 (Los Angeles) (Keiller and Mazzuchi)

"Comparison of two popular Software Reliability Growth Models", at the IASTED 2000 Software Engineering Conference, November 2000 (Las Vegas) (Keiller)

"Enhancing the Predictability of the Littlewood Nonhomogeneous Software Reliability Growth model at the IEEE international Symposium on Software Reliability (ISSRE), November 1999 (Florida) (Keiller and Mazzuchi)

"The Littlewood-Verrall Software Reliability Growth Model revisited-again" at the Second International Software Assurance Certification Conference (ISACC 2000), September 2000; (Virginia) (Keiller)

### **Conference Papers Presented**

"Measurement of Requirements: A Case Study," Proceedings of the International Function Point Users Group Conference, September 22-25, 1998, Orlando, FL, pp. 141-148. (Leach)

"Assessment of COTS Products from an Operating Systems Perspective," Pacific Northwest Quality Conference, October 12-15, 1998, Portland, OR. (Leach)

"Using Reuse to Drive Requirements," IASTED Conference, Las Vegas, NV, October 28-31, 1998. (Leach)

"Enhancing the Predictability of the Littlewood Nonhomogeneous Poisson Procee Software Reliability Growth Model". Accepted to the IEEE International Symposium on Software Reliability (ISSRE), Florida, 1999. (Keiller)

"Predicting the reliability of software systems using Neural Network models". Presented at the National Technical Association (NTA) 70th Annual Conference, November 1998. (Graduate students: Md Abedin and Stephen Arhin). (Keiller)

"Enhancing the Predictability of two popular Software Reliability Growth Models". Accepted to the SAICSIT'99 Conference 1999, South Africa. (Keiller)

"Enhancing the Predictability of the Goel-Okumoto Software Reliability Growth Model" at The International Conference in Reliability and Survival Analysis, May 21-24,1998; Illinois, USA. (Keiller)

"Predicting the reliability of software systems using Neural Network models". Presented at the National Technical Association (NTA) 70th Annual Conference, November 1998. (Graduate students: Md Abedin and Stephen Arhin). (Keiller)

"Improving the Predictability of the Musa-Okumoto Software Reliability Growth Model". Accepted to the First International Software Assurance Certification Conference (ISACC'99). (Keiller)

"Improving the performance of the Goel-Okumoto Software Reliability Growth Model using censored Data analysis techniques". Submitted to the ESAE'99 Conference, Keele University, U.K. (Keiller)

"Using Software Reuse to Drive Requirements," Fourth Baltic Information Science Conference (IEEE), Vilnius, Lithuania, May 1-5, 2000.

"Wireless Remote Mirroring", L. Burge, R. Hemmings, 2000 National Conference National Technical Association, Oct. 2000.

"A Ubiquitous Stable Storage for Mobile Devices", L. Burge, S. Baajun, 2000 National Conference National Technical Association, Oct. 2000.

"Toward a Fault-Tolerant Distributed Jini Environment", L. Burge, G. Harriott, 2000 National Conference National Technical Association, Oct. 2000.

"A Hybrid Solution for Providing Wireless Access and Terminal Mobility in CORBA", L. Burge, B. Turgott, 2000 National Conference National Technical Association, Oct. 2000.

### **Technical Reports**

"Testbeds in Avionics and Aerospace", HUFAST-03-99 Technical Report.

"Embedded Systems and Fault-tolerance". HUFAST-04-99 Technical Report.

"Fault-tolerance in Distributed Databases". HUFAST-05-99 Technical Report.

"Fault-tolerant Network Protocols: Control Area Network (CAN)". HUFAST-06-99 Technical Report.

"Introduction to Fault-tolerant Network Protocols". HUFAST-07-99 Technical Report.

L. Burge, Y. Hu, A Design Pattern for Constructing Reliable CORBA Components, Dept. of Systems and Computer Science, Howard University, Spring 2000.

L. Burge, R. Hemmings, Wirelss Remote Mirroring, Dept. of Systems and Computer Science, Howard University, Spring 2000.

L. Burge, S. Baajun, A Ubiquitous Stable Storage for Mobile Devices, Dept. of Systems and Computer Science, Howard University, Spring 2000.

L. Burge, G. Harriott, Toward a Fault-tolerant Distributed Jini Environment, Dept. of Systems and Computer Science, Howard University, Spring 2000.

L. Burge, B. Turgott, A Hybrid Solution for Providing Wireless Access and Terminal Mobility in CORBA, Dept. of Systems and Computer Science, Howard University, Spring 2000.

L. Burge, S. Curry, A Fault-tolerant Hybrid Directory Protocol for DSM, Dept. of Systems and Computer Science, Howard University, Spring 2000.

M. Garuba, L. Burge, Detection and Avoidance of Denial of Service Attacks, Dept. of Systems and Computer Science, Howard University, Spring 2000.

## **INTERACTIONS/TRANSITIONS**

### **Participation/Presentations at Meetings, Conferences, Seminars, Etc.**

Reuse, Components and Architectures, Third Reuse NSA Symposium, August 20-21, 1997.

Interactions with Fannie Mae, Intel, and others.

HUFAST representatives visited Sandia Laboratories, Albuquerque, New Mexico, December 4, 1996

Participated in the 1997 ADMI Conference in Washington, DC, 29 March - June 2, 1997

Reuse, Components and Architectures, Third Reuse NSA Symposium, August 20-21, 1997.

Interactions with Fannie Mae, Intel, and others.

HUFAST representatives visited Sandia Laboratories, Albuquerque, New Mexico, December 4, 1996

Participated in the 1997 ADMI Conference in Washington, DC, 29 March - June 2, 1997

"Position Paper on the use of Software Maintenance Data to Improve the Maintenance Process," IEEE Workshop on Empirical Studies of Software Maintenance.

Keynote Address at EASE'97, Proceedings of the Empirical Assessment in Software Engineering Conference, March 24-26, 1997, Keele University, UK.

"Software Reuse in Changing Technology Environments," Eighth Workshop in Software Reuse (WISR-8), March, 1997, Columbus, Ohio.

"A Software Metric for Logical Errors and Integration Testing Effort," Proceedings of the Computer Assurance Conference, COMPASS'97, Gaithersburg, Maryland, June 18-20, 1997.

"Experiments In Software Reengineering", Proceedings of the National Aeronautics and Electronics Conference (NAECON'97), Dayton, Ohio, July, 1997.

"Defining 'System'—An Engineering Point of View," 1997 Annual Conference of the International Council on Systems Engineering (INCOSE), August 1-8, 1997, Los Angeles, California.

"Systems and Computer Science: a Curriculum for the Twenty-First Century," 1997 Annual Conference of the ASEE ECE, June 15-18, 1997, Milwaukee, Wisconsin.

"Developing and Sustaining a Sponsored Research Program," 1997 Annual Conference of the Association of Computer and Information Science/Engineering Departments at Minority Institutions (ADMI), May 29-June 2, 1997, Washington, DC.

"Software for Simulation in HUFAST," 1997 Annual Conference of the Association of Computer and Information Science/Engineering Departments at Minority Institutions (ADMI), May 29-June 2, 1997, Washington, DC.

"On Modeling the Query Processing-Relevant Complexity of 2-D Spatial objects", Proceedings of NAECON'97, in press (1997).

"Supporting Team Decision-Making With Consensus-Relevant Information", Proceedings of NAECON'97, in press (1997).

"Generating Belief Functions from Qualitative Preferences: An Approach to Eliciting Expert Judgments and Deriving Probability Functions", Data & Knowledge Engineering, in press (1997).

"A Qualitative Discriminant Approach for Generating Belief Functions", IEEE Transactions on Knowledge and Data Engineering; in press (1997).

"W-Efficient Partitions and the Solution of the Sequential Clustering Problem", Annals of Operations Research: Nontraditional Approaches to statistical Classification and Regression; in press (1997).

"Experiments in Program Comprehension and Reengineering," Proceedings of the Empirical Assessment in Software Engineering Conference (EASE), March 24-26, 1997, Keele University, UK.

"Simple Tools for Reengineering," NASA IV&V Center, Morgantown, WV, April 25, 1997.

"Reuse, Architectures, and Requirements," Third Reuse NSA Symposium, August 20-21, 1997.

"Assessment of COTS Products from an Operating Systems Perspective," Pacific Northwest Quality Conference (R. Leach)

"COTS Assessment," panel at Reuse'98, Morgantown, VA, August 25-27, 1998. (R. Leach)

"Software Reuse: Positive or Negative," tutorial at Reuse'98, Morgantown, VA, August 25-27, 1998. (R. Leach)

"Software Reuse, Components and Architectures," Fourth NSA Reuse and Reengineering Symposium, Laurel, Maryland, August 22, 1997. (R. Leach)

"Developing Network Engineers at Howard University " Accepted by The American Society of Engineering Education Conference, Washington D.C., November 6-7, 1998. (P. Keiller and D. Lloyd)

"Implementation and Exploitation of Massively Parallel Processing," Report to US Army, Contact N. 634215, Dec. 1997. (Naren Vira)

"Generating Consensus Fuzzy Cognitive Maps," International Conference on Intelligent Information Systems, December 1997.

"Complementing Graduate Research and Education with Simulation Models," Proceedings of ADMI 98 (Assessment and Vision The Symposium on Computing at Minority Institutions) Houston TX, June 24-28, 1998. (John Trimble)

"Simulating a Software Development Environment," Proceedings of ADMI 98 (Assessment and Vision The Symposium on Computing at Minority Institutions) Houston TX, June 24-28, 1998. (Ali, Khalid and Radhika Basavaraju)

"A Systemic Approach to Infusing Simulation into a Computer Science Curriculum," ASEE Regional Conference, Washington D.C., November 7, 1998. (John Trimble)

"Classifying Systems," Presented at the 1998 Annual Conference of the International Council on Systems Engineering (INCOSE). (A. Paul)

"Defining 'System'-An Engineering Point of View," 1997 Annual Conference of the International Council on Systems Engineering (INCOSE), August 2-7, 1997, Los Angeles, California. (A. Paul)

"Software Reuse: Positive or Negative," tutorial at Pacific Northwest Quality Conference, Portland, OR, October 12-14, 1998. (R. Leach)

"Measurement of Requirements: A Case Study," Metrics Symposium (R. Leach)

"Quality Issues In Systematic Software Reuse," tutorial to IASTED Conference (R. Leach)

"Using Reuse to Drive Requirements," IASTED Conference (R. Leach)

"A Benchmark Method to Evaluate the Performance of Supercomputers from the Application Point of View", submitted for December Conference, 6th International Conference in Robotics and Manufacturing, Banff, Canada. (Venu Ravi and Naren Vira)

"A Simulation based Computer Science Curriculum, International Conference on Simulation and Multimedia in Engineering Education (ICSEE '99) January 17-20, 1999. (John Trimble)

The Twenty-Ninth Annual Symposium on Fault-Tolerant Computing, Madison Wisconsin, June 15-18, 1999. (Keeling and Vera)

5th USENIX COOTS '99: Conference on Object Oriented Technologies and Systems. San Diego, CA May 5th 1999. (Burge)

ACM Java Grande Conference, San Francisco, CA June 12, 1999. (Burge)

Interactions with NASA, Sohar, Quality Research Associates, Inc. and others  
(Keeling, Goodson, Leach)

Attended International Conference on Dependable Systems and Networks, FTCS-30 and DCCA-8. New York, NY, USA, June 25-28, 2000

Interactions with Fannie Mae, Intel, and others.

HUFAST representatives visit the Marine Corps at Quanico, VA., 27 September 1996

Systems Command of the Marine Corps visited HUFAST, 1 October 1996

National Imaging and Mapping Agency visited HUFAST, 1 November, 1996

Col. Jan Cerveny visited HUFAST, 6 November, 1996

HUFAST representatives met with Boeing, 8 November 1996

HUFAST representatives visited Kirtland Air Force Base, Albuquerque, New Mexico, 5 August 1996

HUFAST representatives visited Sandia Laboratories, Albuquerque, New Mexico, 4 December, 1996

HUFAST representatives visited with Phil Message, Stanford Technologies, Inc. (STEL) 7501 Forbes Blvd off of Greenbelt in Seabrook, MD to get a demo of the DSDS software, 11 December 1996

HUFAST representatives participated in a three day project meeting with SAIC, 22 – 25 January, 1997

HUFAST representatives participated in a three day project meeting with SAIC in Daytona, Florida, 25 – 27 March 1997

HUFAST representatives Attended the Fifth Annual Industry Briefing on Modeling and Simulation by NTSA/DMSO, May 22 - 23, 1997

HUFAST co-sponsored the 1997 ADMI Conference in Washington, DC, 29 March – June 2, 1997

HUFAST representatives visited Air Force base in Rome New York, 9 June 1997

HUFAST representatives attended the Summer Simulation Conference, Washington, DC, 13 –17 July 1997

HUFAST representatives attended a briefing “Minority Institutions of Higher Education Research Strategies and Funding Opportunities,” Langley, Virginia, 23 July 1997

#### **Consultative and Advisory Functions to Other Laboratories and Agencies**

Software Reuse and Metrics, NASA/Goddard Space Flight Center, Greenbelt, Maryland  
Henry Murray, Kellyanne Jeletic

Software Reuse and System Architectures, NSA, Laurel, Maryland  
Noreen Centafont (ongoing)

Dr. Burge served as a reviewer on advisory committee for Kansas State University, Department of Computer and Information Systems. This research, headed by Mitch Nielsen, examines "Reliable Software Components for Real-Time Systems"

**Transitions**

All but one of the HUFAST-supported students successfully completed their MS degrees in Computer Science.

**NEW DISCOVERIES, INVENTIONS, OR PATENT DISCLOSURES**

None.

**HONORS/AWARDS:**

None.